AGRICULTURAL ENGINEERING

Published monthly by the American Society of Agricultural Engineers
St. Joseph, Michigan

Subscription price to non-members of the Society, $3.00 a year, 30 cents a copy; to the members of the Society, $2.00 a year, 20 cents a copy. Postage to Canada, 50 cents additional; to foreign countries, $1.00 additional. Entered as mail matter of the second class, June 25, 1921, at the post office at St. Joseph, Michigan, under the Act of August 24, 1921. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

The American Society of Agricultural Engineers is a member of The Federated American Engineering Societies.

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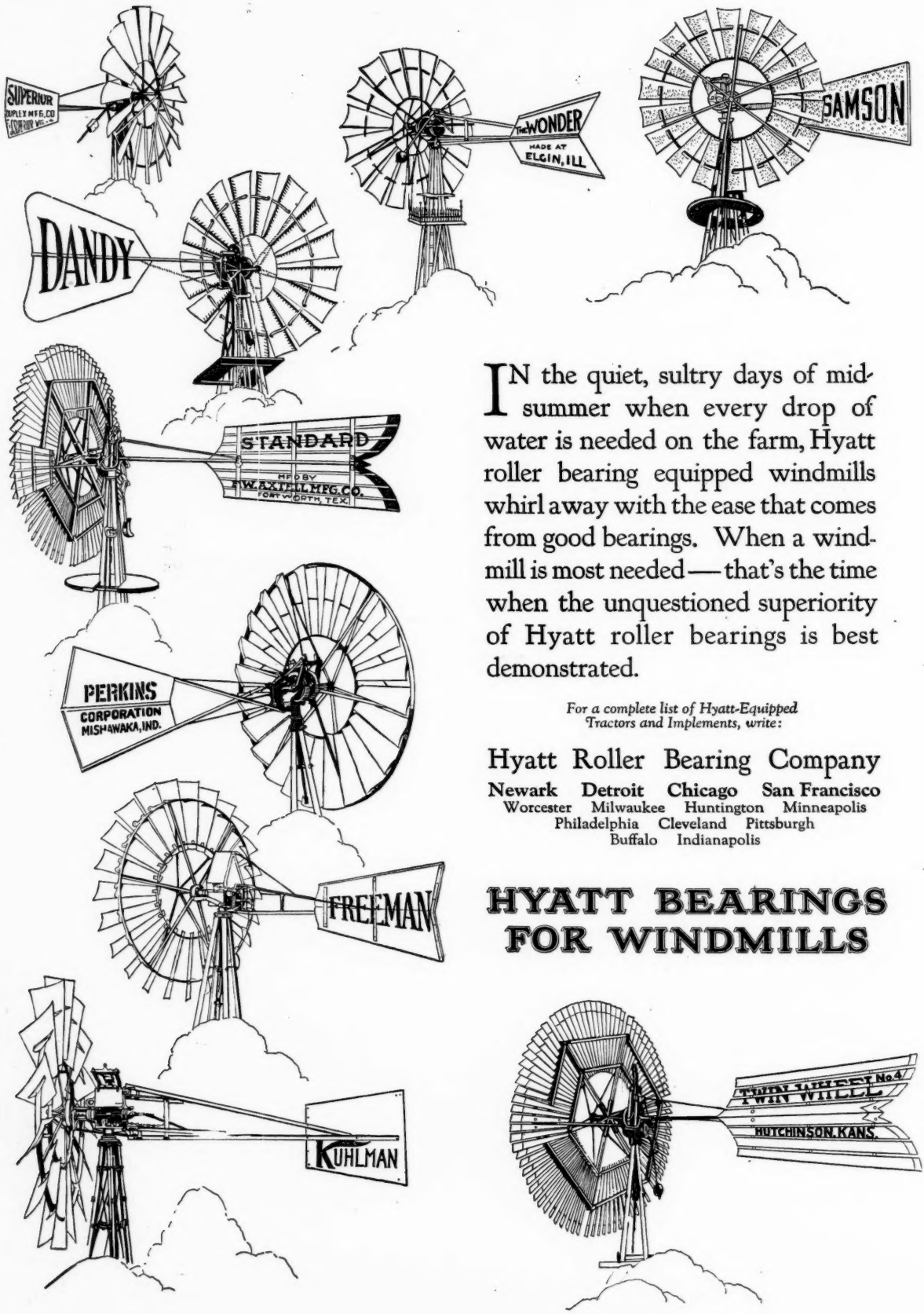

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Vol. 4 MARCH, 1923 No. 3

Some New Ideas in the Group Planning of Farm Buildings*

By F. W. Ives
Mem. A.S.A.E. Professor of Agricultural Engineering, Ohio State University

ONE hesitates to speak of new ideas in the grouping of farm buildings, because almost every sort of grouping possible has been tried at one time or another, either by chance or design.

It is safe to say that a large proportion of American farm building groups are the result of accident or force of circumstances imposed by thoughtless ancestors rather than a studied plan based on economic and climatic conditions. When one looks at some groups he is almost forced to believe that the buildings were located in a particular place because the farmer, driving in with a load of lumber, had got stuck in the mud and built where he was forced to unload.

Some early groups were located where there was easy access to water; others where there was a good road to town, both sufficiently good reasons, but only one reason for location.

There is no use repeating to this audience any but the briefest mention of points to be considered in the location of the group. The principal points are:

1. Good drainage, natural or artificial.
2. Air drainage.
3. Accessibility to market or highway.
4. Accessibility to fields.
5. Shape of farm.
6. Topography of country (Implied in 1 and 2.)
7. Soil.

These points have all been discussed in previous papers presented before this Society. The purpose of this paper is to discuss some of the newer economic considerations facing the designer of farm buildings. When a man could go out into his woodlot with labor at 50 cents a day and hew out a barn frame, take a few logs to mill and get his lumber sawed out at $2.00 per thousand board feet and pay out cash only for hardware, limits on size were not so important. It was possible to build large driveways in barns that had no other purpose than a place to drive in and unload hay in the summer and a feeding alley in the winter.

If the buildings took fire and burned, they were easily replaced out of insurance, and, after a fashion, a man was to be congratulated upon the opportunity to rectify the mistakes committed in the previous structure. Not so today. The farmer finds that his insurance is only one-third or one-fourth enough to replace the burned building.

The factors that must be considered by the agricultural engineer today are both structural and economic. They may be named:

1. Labor, skilled and unskilled (construction).
2. Material, native (local) or imported.
3. Expected depreciation.
4. Capital charge.
5. Fire hazard.
6. Relation to size and character of farm.
7. Convenience of operations.
8. Mechanical equipment.
9. Upkeep.
10. Ease of remodelling or enlargement.
11. Interrelation of buildings.
12. Appearance.

1. LABOR. The labor problem is a serious one in the

*Sixteenth annual meeting paper.

PROPER LOCATION IS AN ESSENTIAL PART OF A BUILDING

Millions of hours are wasted and uncounted shoes worn out in needless steps among poorly located farm buildings every year. Farm fire losses are much greater than they need be due to unwise grouping of combustible buildings, stacks, etc. Since fire protection and efficiency are in some ways conflicting, and related to the building material and system of farming there is need for the agricultural engineer, as well as architectural service

building industry. The hours are so short and the skilled tradesmen so few that the law of supply and demand has caused the cost of building to soar. Nor is there much relief in sight. We like to talk, as we should, about permanence in construction, yet brick and stone masons, stone cutters, form builders and steel workers are our highest paid workmen, and in many cases do the least for the money paid them. This summer, for example, I timed a bricklayer taking a chew of tobacco. It took ten minutes from the time he laid down his trowel until he picked it up again. At $1.50 per hour, this cost the contractor 25 cents! Of course, the contractor passes it on if he is a good business man and collects 2½ cents if he is working on the cost plus percentage basis. Another brick mason was overheard on a street car boasting of having laid but 196 brick that day for which he received $12. "Pretty soft!" These were his words. At $20 per thousand the brick were worth $3.92 and it cost three times that just to lay them, to say nothing of tender, foreman, staging, mortar, etc. Those brick cost not less than $75 per thousand in the wall.

The bricklayer is probably no worse or no better than any other trade except perhaps more independent. These incidents are merely quoted to give you the idea that we must study and standardize, must use materials that may be handled by the less skilled trades, or must design structures in such a way that time is utilized to the best advantage.

2. Material. Material costs are largely a matter of transportation and labor plus middlemen's profits. If we can utilize the materials at hand, there is a chance to reduce cost to a minimum, provided the labor charge in incorporating the material into the structure is not greater than for imported material. Fortunately, for the most part, permanent materials are fairly well distributed, that is, concrete materials and clay products. The use of permanent materials should be encouraged or even urged unless the cost is excessive over that of other materials.

3. Depreciation. The depreciation of buildings is a matter partially in the hands of the designers. A rational balance between first cost and cost per year of useful life and the ability of the owner to pay are, or should be first in the mind of the designer. These points should be carefully explained to the client, he of course having final authority.

Depreciation comes about from natural causes such as weather or climate or insects, from disuse, from obsolesence, and from wear and tear. Careful design as to material, its treatment, the selection of material as to best use, good foundation and good roof will decrease natural depreciation and wear and tear. Obsolesence is cared for in the design by building in such a fashion that the building is in units of a character that allow easy adjustment and remodelling or addition. Disuse alone cannot be foreseen.

Studies by rate commissions, tax and insurance experts all show to advantage for buildings of the more permanent materials.

4. Capital. Obviously a building must be reasonable in first cost else the owner will have a tremendous interest charge. Some "play" farmers, not having any idea of income from the farm, expend enormous sums for fancy buildings. When their fancy passes or their heirs-at-law dispose of the holdings a great loss is incurred, and even then the buyer frequently puts his neck in a noose, because of the tremendous upkeep expense of the buildings.

The best building, for whatever purpose, is that building that best fulfils its function at the lowest cost per year of useful life. Taxes, interest, upkeep and depreciation are the measure of one side of the efficiency equation.

5. Fire Hazard. Most farm buildings cannot be rendered fireproof on account of the large amount of inflammable materials stored in them. They may be rendered fire-resistant and fire safe by proper materials and design. It seems to be good policy to fireproof a barn to the hay mow floor, as it may be done at a reasonable cost. To build an actual fireproof roof in view of the hay stored, would saddle too much overhead onto the farmer. He would be better off, in the case of fire, to sweep the ashes off the hay mow floor and put on a new roof with his insurance money than to live under a crushing burden of interest on a large investment.

Good roofs, good electrical wiring, lightning rods, good flues, lessons on the care and handling of lanterns, stoves, gasoline and matches, and a few hand extinguishers about a place will lessen insurance charges and reduce the fire loss of farmers at least 75 per cent.

6. Relation to Size and Character of Farm. Buildings should function according to the needs for them. Overbuilding is poor economy. Inadequate buildings are also poor economy. If a farm is studied, the buildings may be built to suit the probable income and requirements. Probable enlargements to farm or increase in production may be taken care of by provisions for expansion. Unit construction lends itself well to expansion.

7. Convenience of Operation. Convenience of operation is essential because it helps to keep down cost per year and is therefore a matter for thorough study. This applies equally well to buildings in groups or singly.

8. Mechanical Equipment. No part of the design should be given more careful study than the mechanical equipment. Because of its high first cost and rapid depreciation if poor, and because of its economy of man power if good, mechanical equipment will make a great difference in operating expense. Some farms are needlessly overequipped because of duplication of units or thoughtless installation. Of two evils underequipment is the lesser, provided an otherwise convenient arrangement of mows, alleys, passages, and doors is made.

9. Upkeep. Upkeep consists of such items as painting, repairs on spouts, gutters, roof, floors, and hardware. Upkeep is not necessarily connected with depreciation but generally closely related to it. A building may be repaired without decreasing depreciation materially, but failure to repair will hasten depreciation greatly.

Upkeep charges may be lessened by using materials not requiring paint or preservatives, by using lasting materials for roofs, flashings, gutters, spouts and by careful selection of floor materials.

In a floor of experimental nature at the Ohio State University, in which seven different materials were used in as nearly identical conditions as possible, two have shown practically no depreciation in 5½ years. These were wood block, creosoted, on a concrete base and paving brick on a concrete base.

Conditions such as comfort of animals, wear on shoes, etc., favor the wood block. Here then is an example of selection for purpose as well as depreciation. Other types of floor showed a rather high maintenance cost although favorable in other respects.

10. Ease of Remodelling or Enlargement. To repeat, standardized plans enable one to construct buildings in such a way that they may be enlarged or remodelled with ease. The proposed A. S. A. E. standardized barn plans meet this requirement in a very satisfactory way. Hog houses and machinery sheds are also easily capable of enlargement. The farm house is the one building that can have no definite standard since families cannot be standardized readily.

11. Interrelation of Buildings. The factory system building arrangement is practical upon almost any type farm. In this arrangement, the work is carried on pro-

gressively from one building to the next. This is clearly illustrated in the University of Nebraska studies and ably set forth in bulletins of the Nebraska station.

With the introduction of fire-safe materials, water pressure on the farm, and chemical fire extinguishers, it is possible to group buildings as closely as good yard connections will allow. Some newer groups are connecting the buildings with covered passageways, the passageways being entirely of fireproof materials. With partition walls of brick or concrete, the spread of fire may be prevented if metal covered, self-closing doors are used on all openings.

Aside from the advantage of protection for those doing the work, the group may be arranged to form a court yard for the protection of animals.

12. APPEARANCE. The compact building group is capable of a superior arrangement for appearance sake. In our intense practicality we are apt to overlook the value of appearance as an asset to the farm. Where buildings are widely scattered, great care must be taken in the design if unity is attained. The court system, whereby all buildings are grouped around a central court, is likely to give the best results from almost every standpoint.

Tests of Low Lift Pumps Used in Cranberry Growing*

By C. I. Gunness

Mem. A.S.A.E. Professor of Rural Engineering, Massachusetts Agricultural College

ONE of the important industries on Cape Cod is the growing of cranberries. A total of 14,000 acres of bog is now in bearing with a yield of from 120,000 to 455,000 barrels per year. The serious hazards in growing the cranberry crop are winter-killing, frost and insects, and relief from them all is obtained mainly by flooding. While many bogs can be flooded by gravity, often water is available only by pumping from lower levels. Where water is pumped, the lift usually is low, ranging from 2 to 12 feet. It is estimated that there are about 120 pumping plants on the Cape, the power for the plants being provided by gasoline engines of from 10 to 60 horsepower, the most common being 25 and 40 horsepower. Two pumps driven either by one or two engines are sometimes installed. In flooding to protect the vines from frost, the bog floor must be covered to a depth of about two inches. As really reliable frost warnings are not available until after 9:00 P. M., and the bog often must be protected before midnight, the pumping plants must be reliable and of large capacity. Bogs served by a single pump vary in size from 5 to 30 acres. For larger areas it is customary to put in two or more pumps. The cost of pumping plants ranges from $500 to $4,000.

*Sixteenth annual meeting paper.

At the request of the Cape Cod Cranberry Growers' Association, a series of tests to determine the capacity and efficiency of the pumps commonly used on the Cape were run at the Massachusetts agricultural experiment station at Amherst. The testing plant was erected in August, 1922, and the tests were run during September. The construction work and the tests were carried out by the rural engineering staff of the Massachusetts Agricultural College.

The general arrangement of the testing plant is shown

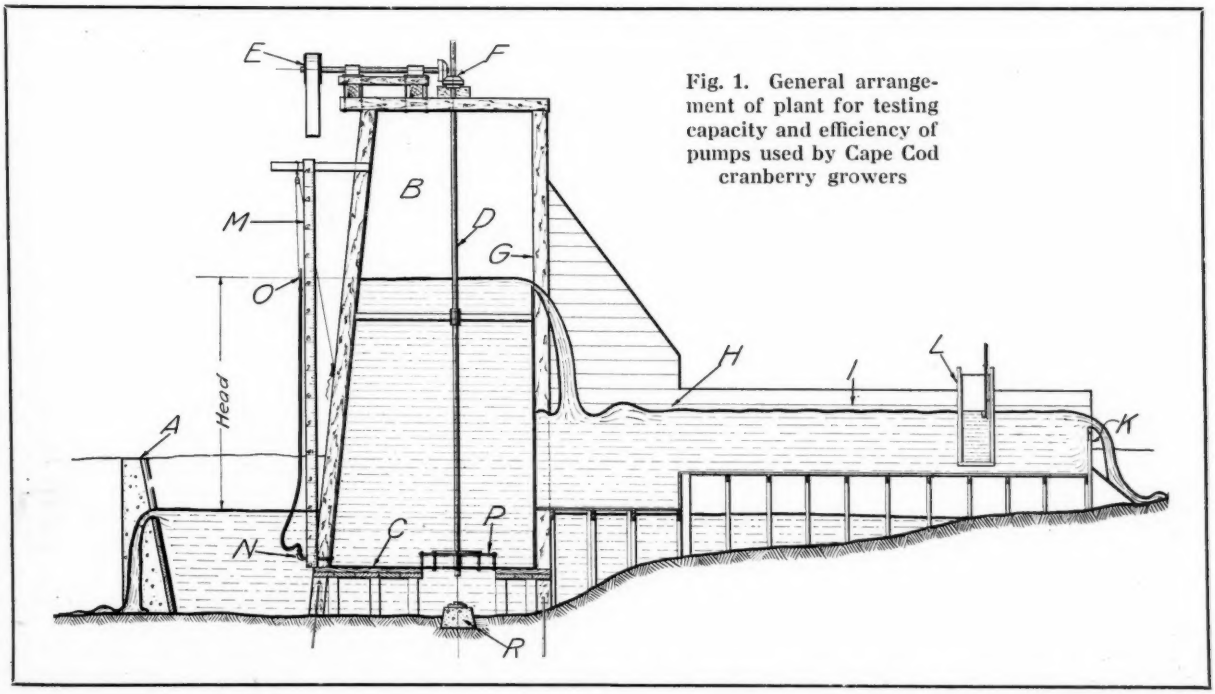

Fig. 1. General arrangement of plant for testing capacity and efficiency of pumps used by Cape Cod cranberry growers

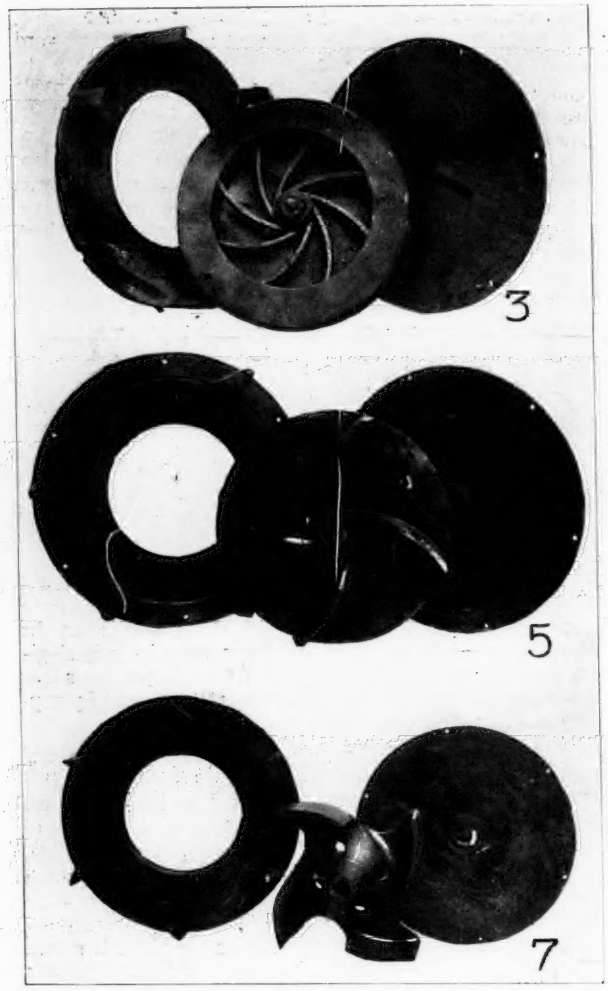

Fig. 3. Showing construction of Gray-Aldrich pump
Fig. 5. Showing construction of Bailey pump
Fig. 7. Showing construction of Ward pump

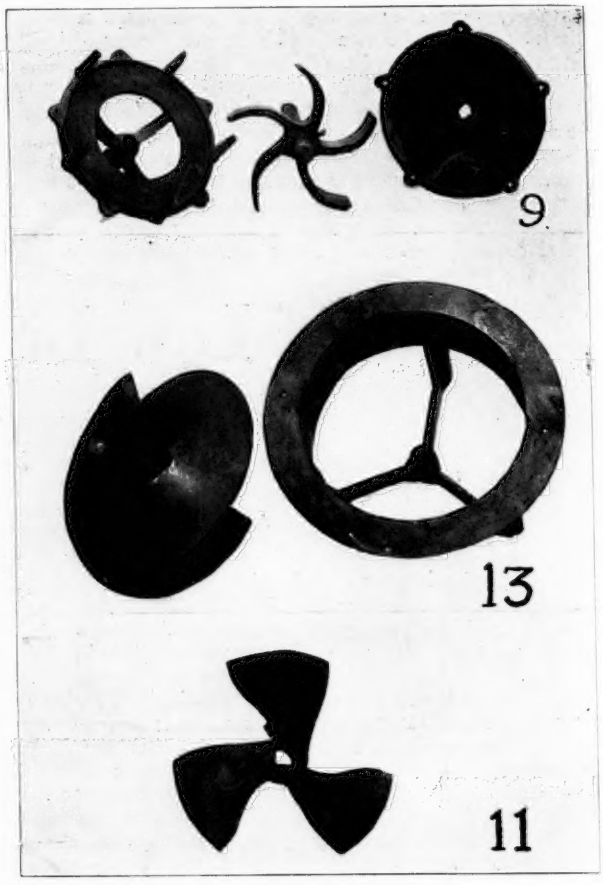

Fig. 9. Showing construction of Smith pump
Fig. 13. Showing construction of Malde pump
Fig. 11. Showing construction of Jager pump

in Fig. 1. The plant was located in a small brook which runs through the college campus. This brook, which is ten feed wide, was damned by a five-foot dam, A, provided with gates so that water could be raised to any desired height. The tower, B, was rectangular, 8 feet square at the base and 18 feet high. One side was sloped in so that the measurement at the top was 6 by 8 feet. A floor or deck, C, carried the pump, P, which was driven by the shaft, D. Power was obtained from a 40-horsepower induction motor driving the pulley, E, through a double 8-inch leather belt. The bevel gears, F, were machine cut gears with a ratio of 19 to 39. Ball bearings were used to take the thrust from the bevel gears and plain bearings at all other points. Gates were provided on the wall, G, to give the desired discharge head, the water dropping into the box, H, and from there being led through a 5-foot flume, I, to the weir, K. This weir was a suppressed weir 5 feet wide and 18 inches high. A hook gauge reading to 0.001 foot was installed in a stilling box, L, outside of the flume and 6 feet back from the weir. For the propeller pump a bearing was provided on the base, R.

In order to measure the head against which the pumps were operating, a scale, M, was placed on the outside of the tower with the zero point at the level of the floor, C. A ¾-inch garden hose was attached at N and equipped at the end with a glass tube, O, the upper end of the hose being raised and lowered by a rope running over a pulley so that the height of the water in the glass tube could be read on the scale. Since the height in the glass tube was the same as the height in the tower, the head pumped against could be determined by reading the brook water level and the water level in the glass tube on the same scale. The difference between the two readings gave the actual head, which by this means could be read to 0.01 of a foot.

The pumps were run at a number of speeds, and at each speed the lifts varied between 3 and 12 feet. Before starting a run the side, G, was boarded up to the top, the pump started and operated until the weir reading became constant. The head, weir, wattmeter and speed were then read simultaneously and recorded. The head was next decreased by removing boards from the discharge side and in some cases by raising the water in the brook. A second set of readings was taken when conditions became stable, and this method was followed successively until the pump was operating under the minimum head. The power required to operate the pumps was measured by the use of a wattmeter. The discharge over the weir was calculated according to King's formula, $Q = 3.34LH^{1.47}\left(1 + 0.56\frac{H^2}{d^2}\right)$ so as to obtain the relation between gross horsepower input as indicated by the wattmeter and net horsepower delivered to the pump. With the pump removed, a Prony brake was attached to the pump shaft. A brake test was then made

for each of the speeds at which the pumps were operated. From this brake test it was possible to find the net horsepower delivered to the shaft for various wattmeter readings.

The results of the brake test are shown in Fig. 2. In this diagram the net horsepower curve is obtained by plotting horsepower against wattmeter readings. The lower line shows the net horsepower delivered by the motor for various wattmeter readings. This curve was obtained from a chart provided by the manufacturer of the motor. The horizontal distance between the two curves represents the combined loss in belt, bearings, and bevel gears. The efficiency of the transmission system, from motor pulley to pump, is shown by the third curve.

The performance of the various pumps is shown by a set of three curves for each pump. These are: (1) Capacity in gallons per minute; (2) horsepower required to operate the pump, and (3) efficiency. To illustrate the use of the curves, let us assume that we wish to find the characteristics of a pump operating at a certain speed on a 6-foot head. by the use of the tables given in King's "Handbook o: Hydraulics."

In order to eliminate from the final computations the loss in the motor, belt, bearings and gears, a brake test was run Follow the vertical line passing through "6" at the base of the drawing until it intersects the capacity curve. Follow the horizontal line which intersects the capacity curve at this point to the capacity scale on the left of the sheet, and flow in gallons per minute can be read directly. Readings for power and efficiency can be made in the same manner.

The power curve shows the actual power delivered to the pump. In designing a plant, allowance must be made for the loss in transmission. If, for instance, the curve shows a power consumption of 20 horsepower for assumed conditions, an engine must be provided which will develop more than 20 horsepower, if the pump is to be driven up to the indicated speed. As a general rule, a 25 per cent increase will be sufficient to take care of transmission losses.

The efficiency indicated by the curves is the ratio between the horsepower represented by the water pumped and the net horsepower supplied to the pump, the losses in the transmission system having been deducted.

Three types of pumps were tested. The first four shown (Figs. 3, 5, 7, 9) are of the open centrifugal type, the fifth (Fig. 11) is a propeller pump, and the last (Fig. 13) an auger pump. The open centrifugal pump is a special form of this type which has been developed for low lifts. It may be said to be a standard vertical centrifugal pump with the periphery of the casing cut away. The construction of the last two (Figs. 11 and 13), as well as their performance characteristics, are very similar.

Fig. 3 shows the Gray-Aldrich pump, one of the largest tested. The impeller or runner is 29 inches in diameter and has eight blades. The suction inlet is 20 inches in diameter. The performance of the Gray-Aldrich pump is shown in Fig. 4. It will be noticed that both the capacity and power fall off gradually as the head is increased. The maximum efficiency for a speed of 260 r. p. m. is reached at a 10-foot head, while the highest efficiency for the higher speed of 300 r. p. m. has not been reached at a head of 12 feet. The probability is, however, that any considerable increase in head would show a decrease in efficiency at the higher speed.

Fig. 5 shows the Bailey pump, which is similar in construction to the Gray-Aldrich. Its runner is also 29 inches in diameter, but it has only 4 blades. The inlet opening is 16 inches. The performance of this pump, shown in Fig. 6, is very similar to that of the Gray-Aldrich. Its efficiency curve does not reach quite as high a point as the latter, but it shows a better average over the full range of head from 4 to 12 feet. The runner in this pump rubbed when the pump was started and the first data obtained had to be discarded. The power required to operate the pump fell off as the runner wore down, but we are not sure that the runner was entirely free when the test run was made.

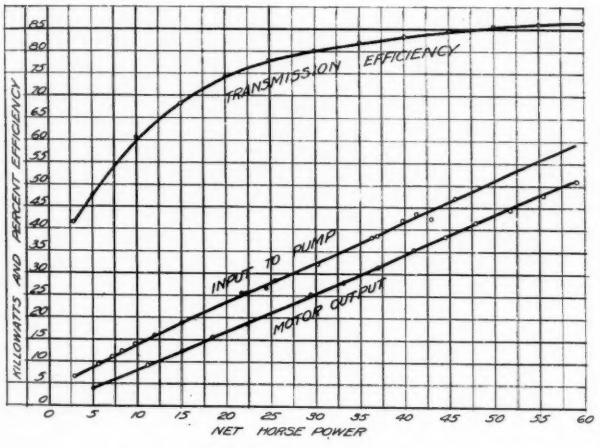

Fig. 2. Transmission efficiency curves

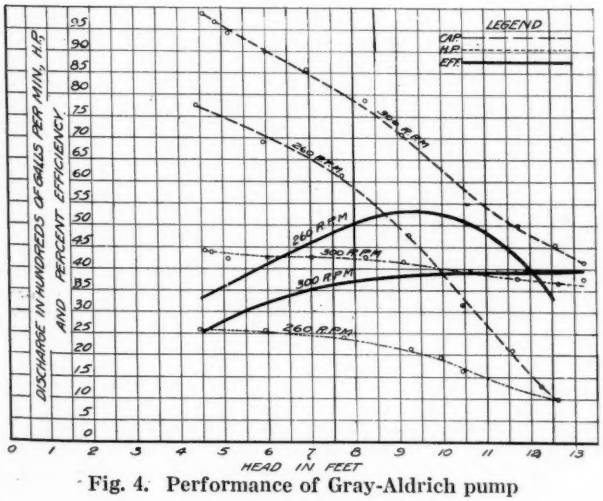

Fig. 4. Performance of Gray-Aldrich pump

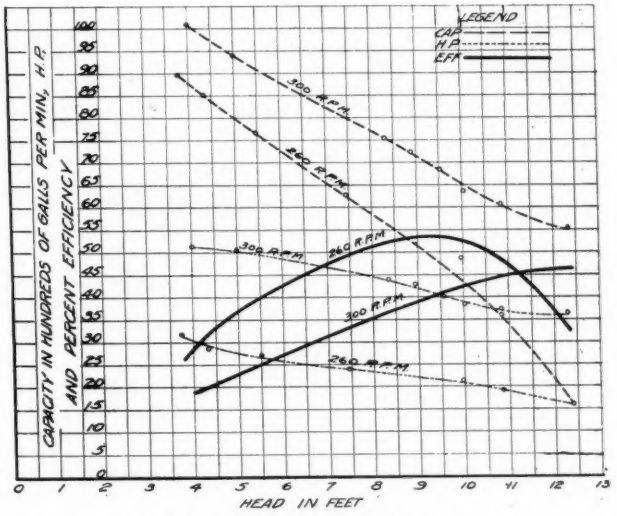

Fig. 6. Performance of Bailey pump

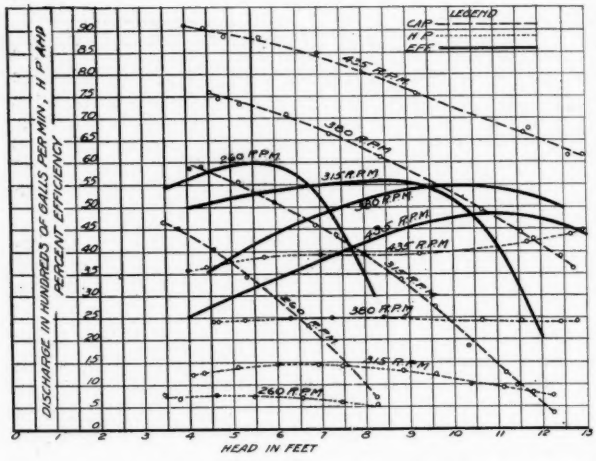

Fig. 8. Performance of Ward pump

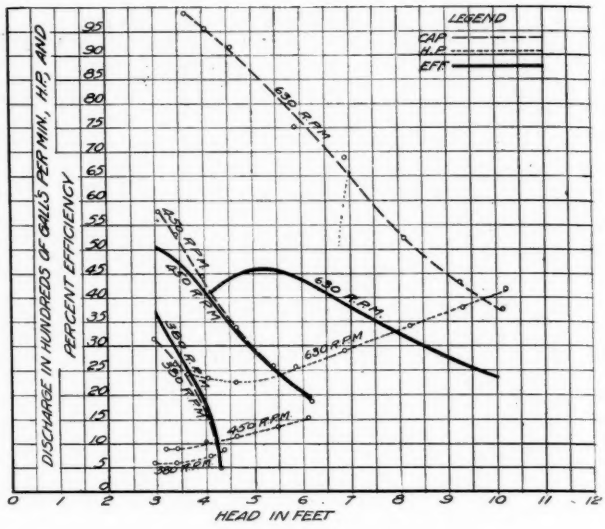

Fig. 12. Performance of Jager pump

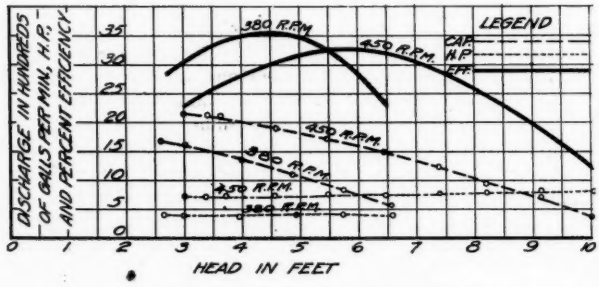

Fig. 10. Performance of Smith pump

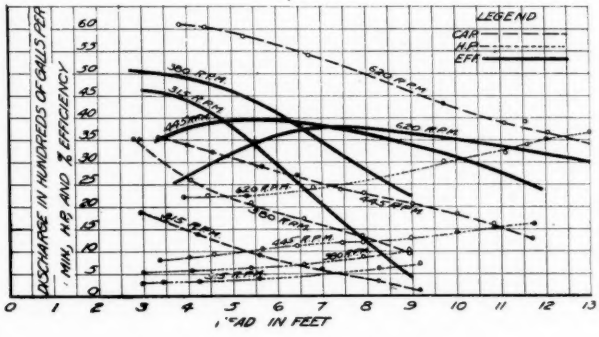

Fig. 14. Performance of Malde pump

The Ward pump is shown in Fig. 7. It has a 24-inch runner the blades of which are curved quite differently from the two which have been discussed. The suction opening is 15 inches. The curves shown in Fig. 8 indicate the performance of this pump. This pump is of course much smaller than the two which have been discussed, but the efficiencies range somewhat higher and hold up over a wider range of head.

Fig. 9 shows the Smith pump. The diameter of the impeller is 16 inches, and the suction opening is 10 inches. The performance is shown in Fig. 10.

Fig. 11 shows the Jager propeller pump. It is a three-bladed propeller, 24 inches in diameter. The performance of this pump is shown in Fig. 12. It will be noticed that the highest efficiency is obtained at very low lifts. The lowest lift which could be had with the testing plant was three feet, and as indicated by the curves, the highest efficiency is obtained on even lower heads.

The Malde auger pump is shown in Fig. 13. This type of pump is comparatively new and none have been installed on the Cape. It has a 24-inch auger running in a cast iron casing. The performance is shown in Fig. 14. As in the propeller pump, the highest efficiency is obtained at very low heads, and only at the highest speed did the pump attain its best efficiency at the heads available.

It is hoped that the results of the tests reported above will be of direct interest and benefit to cranberry growers. The curves obtained may be used in the designing of pumping plants. They show the capacity of the pumps at various speeds for different heads and also the power required to operate them. It is expected, however, that the results will be of more value to the grower indirectly, as they are used by the men who design and install pumps. As an illustration, it may be pointd out that all the open centrifugal pumps show their highest efficiency on low speeds. This indicates that these pumps should be run at a comparatively low speed, and that large capacity should be obtained by enlarging the pump. How far it would be advisable to increase the size of the pump is a problem for the designer.

Some growers may have anticipated that one of the pumps would prove much better than the others and become the pump for all to use. No such results were obtained, as no *one* pump proved superior for all heads. In general, it might be stated that the propeller and auger pumps are more efficient at the very low lifts; while, for the higher heads, a pump of the open centrifugal type probably would give better results. In selecting a pump, it should be borne in mind that one showing high efficiency is not necessarily the ideal pump. Other factors which must be considered are durability, cost, cost of installation, and manufacturer's service.

Research in Agricultural Engineering*

By R. W. Trullinger
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THE purpose of this report is to draw attention to the more prominent features of agricultural engineering experimentation, investigation, and research completed, in progress, or in process of formulation during the year at the state agricultural colleges and experiment stations, certain other state and federal institutions, and certain foreign agricultural and engineering institutions. Attention is also drawn in some cases to work which will be followed at the state experiment stations during the year 1923.

Considerable of the agricultural engineering investigational work being conducted at state colleges and experiment stations is apparently still in charge of departments other than that of agricultural engineering, thus making absolute accuracy and completeness in a report of this nature quite difficult to attain. Furthermore, it has been disclosed that much of the investigational work conducted by state institutions other than the experiment stations is frequently not made public at all. It is known that in some such cases highly important developmental work has been entered into through force of necessity to meet a demand for information, usually for teaching purposes.

During the year a representative of the U. S. D. A. Office of Experiment Stations visited seven state colleges and experiment stations for the special purpose of conferring with officials on the planning of agricultural engineering research. A significant feature of these visits was the evident deep interest of administrative officials in the development of agricultural engineering along fundamental lines. All experiment station directors interviewed expressed a willingness to give carefully prepared projects in agricultural engineering embodying elements of research equal consideration with other agricultural projects in the allotment of research funds. The importance of thorough consideration and planning of a project before bringing it to the attention of a director is thus plainly evident.

Consultation with the agricultural engineering officials at these institutions revealed the existence of numerous unsolved agricultural engineering problems of a highly important and, in some cases, a very pressing nature. The intelligent planning and replanning of certain important projects at these institutions have already had the result that two institutions are preparing to place certain agricultural engineering work on an Adams fund basis, one institution has prevented the suspension of certain of its federal research work, and three other institutions have obtained definite state fund support for research. Reports received from numerous other agricultural colleges and experiment stations indicate that many agricultural engineering departments and divisions are beginning to think along similar lines, and some have taken quite definite and effective steps to place the study of agricultural engineering problems on a research basis in the experiment stations. Everything considered, the outlook for the substantial development of agricultural engineering along fundamental lines is most bright and promising. This may be better appreciated by a careful consideration of some of the more important details of the work itself.

As usual the work in agricultural engineering completed, in progress, or planned during the year included the following general subjects: Farm machinery, farm buildings, drainage, irrigation, farm water supply and sewage disposal, land clearing, materials of construction, and miscellaneous.

*1922 report of Research Committee.

FARM MACHINERY

A striking feature of the farm machinery program for the year has been the discontinuance, suspension, or "completion" of numerous indefinite blanket projects covering a multitude of details and obviously including practically no research features. Agricultural engineering departments are learning that experiment station directors and other officials charged with the administration of research funds are not particularly interested in supporting work of an indefinite nature on a very general subject. On the other hand, cases involving a clear and specific purpose and a well thought out line of approach and method of procedure are likely to receive attention.

This has been particularly true of tractor work. Last year it was noted that several stations had expansive projects in operation covering the general subject of tractors. This year the tendency seems to be to deal with important specific phases of the subject in an intelligent and systematic manner. The Alabama station, for instance, has narrowed its tractor study down to a project on the relation of the physical factors of soil to impulsive traction. The object of this study is to determine the fundamental factors which influence wheel traction and to determine lines of maximum, minimum, and intermediate resistance in soil and lines of maximum, minimum, and intermediate impulsive stress from tractor wheels and lugs, with a view to making lines of maximum impulse coincident with lines of maximum resistance in soil as a basis for the development of the proper shape, size, location, and inclination of lug on a tractor wheel to give maximum impulsive traction on the worst agricultural soils in the state of Alabama. The statement of the object of this study alone gives evidence of an exhaustive and painstaking preliminary analysis and study of the subject. The preliminary results already indicate certain new and striking features, among which is the fact that a tractor has a certain minimum permissible slip for highest tractive efficiency, or, in other words that the highest tractive efficiency is not always obtained by the least slip.

The Indiana station is apparently still engaged in studies to determine the slip of various types of tractor wheel equipment. No accurate information is available as to the research status of this project, but it is suspected that it so far consists merely of comparative tests. It is assumed, however, that the purpose is to determine the best methods available as a basis for a more fundamental study.

The California station has already published a preliminary report on its studies of air cleaners for tractor motors. It is understood that this work constitutes the preliminary elimination study of available types.

A project has been in progress at the Wisconsin station on the effect of kerosene as a fuel upon the lubrication of tractor motors. The results so far have shown that lubricating oil with an initial viscosity of 540 seconds at 100 degrees Fahrenheit deteriorated at the end of 15 hours running so that the viscosity had dropped to an average of 200 seconds. The greatest drop in viscosity occurred during the first 2.5 hours. This work is of special importance to users of kerosene-burning tractors, and opens up an important although not particularly unknown field of study.

In fact, there has been a considerable amount of study in private, state, and federal institutions in this country and

abroad on fuels for and lubrication of internal-combustion engines and tractor motors. Numbered among the foreign institutions are the British Ministry of Agriculture, Bureau of Science at Manila, certain French and German agricultural experiment stations, the Hawaiian Sugar Planters' Association, the agricultural departments of Australia and South Africa, and others. In this country several private institutions have conducted some most excellent research upon both fuels and lubrication.

The tendency in the fuel research has been to develop the use of alcohol fuel and to develop anti-knock materials to mix with hydrocarbon fuels. For instance, it has been found that owing to its low volatility, alcohol treated with ether obtained from alcohol by dehydration makes the best motor alcohol. The action of corrosive compounds formed by the combustion of such a mixture has been found to constitute a serious problem. Investigations so far have shown that the most suitable basic chemicals for neutralizing the corrosive acids produced are the amines either primary, secondary, or tertiary. Tractor tests with such fuels have shown that starting is easy and full power is developed. The fuel consumption in tests averaged 50 per cent more than when gasoline was used, however.

It has been found that about 1 gallon of absolute alcohol can be made from 2.2 gallons of molasses containing 57.7 per cent of sugar. In this connection the South African Department of Agriculture has been studying processes for the bacterial production of tractor motor fuels containing alcohol and acetone. It has been found that acetol, a fuel consisting of alcohol and acetylene gas, owes its properties largely to the fact that the addition of acetone to the alcohol increases the absorption of acetylene gas, thus increasing the calorific value of the mixture. Studies have also been conducted on the production of alcohol from wastes such as corn cobs, pineapple refuse, sweet potatoes, and other organic materials by fermentation with certain organisms such as *Bacillus acetoethylicum* capable of producing alcohol and acetone direct from starchy substances.

It may be well to state at this point that the Alabama station is considering a project on the refining of crude cane syrup. It is understood that this matter has been charged to the agricultural engineering division. The preliminary plan is apparently to take up a study of the refining process in cooperation with the chemistry department. As a means for paying the expense of refining, it is proposed to use the by-products thereof for the manufacture of alcohol motor fuel, the use of which in tractor motors may be developed in the mechanical laboratory.

Studies have been continued in the Belgian Congo on the development of palm oil as an internal-combustion engine fuel. The advantages of this fuel seems to be low carbonization, high percentage combustion, and low consumption of lubricating oil.

The Bureau of Chemistry of the U. S. Department of Agriculture has continued its studies of fuel gas made by carbonizing straw. It has been found that a ton of sun-dried wheat straw will yield approximately 10,000 cubic feet of purified gas, having a calorific value of about 400 B. t. u. per cubic foot.

Studies conducted by the research department of one of the larger private institutions on detonation characteristics of some blended motor fuels and the chemical control of gaseous detonation in internal-combustion engines have yielded some especially interesting and valuable results. It has been found that detonation or knock in internal-combustion engines can be either suppressed or induced by the presence of very small amounts of certain materials in the combustible mixture. The compounds possessing this property are chiefly derivatives of about fifteen elements. Oxygen and the halogens in the elemental form exert a marked effect upon combustion. Iodine is an anti-knock material, while the other elements induce detonation to different degrees. A great many nitrogen compounds are effective anti-knock materials, probably the best of which are the aromatic amines. Certain compounds of selenium, tellurium, tin, and lead are remarkably effective for the suppression of knock, while some compounds of arsenic, antimony, and phosphorus have a marked but lesser anti-knock effect. When benzol was blended with paraffin fuels in percentages larger than twenty, its anti-knock effect increased rapidly as its concentration increased. Toluene on the basis of volume was more effective than benzene for eliminating detonation, and xylene was in turn still more effective than toluene. The addition of 1 per cent of xylidine to a fuel giving incipient detonation made it possible to raise the engine compression about 10 pounds without increasing the detonation. On the volume basis, alcohol was considerably more effective than benzol for the suppression of detonation when blended with a paraffin fuel. The detonating tendency of a fuel composed of two ingredients was found to be greater than the average of the values representing the detonating tendencies of the two components taken separately. A practical test of these results in Germany showed that a fuel consisting of 53 per cent benzol, 34 per cent alcohol, and 13 per cent tetralin gave almost as high a thermal efficiency as pure benzol, and the use of higher compression ratios was possible.

The Massachusetts Institute of Technology has developed approximate methods for determining the total sensible heat contents of internal-combustion engine gasoline and kerosene and their mixtures with air at temperatures up to 500 degrees Centigrade. (932 degrees Fahrenheit), making it possible to calculate with sufficient accuracy for all practical purposes the resultant temperature of an air fuel mixture when the temperatures of the two constituents before mixing are known.

The South African Department of Agriculture and the French Academy of Agriculture have reported some interesting studies on the use in tractor motors of low-grade gas produced by the combustion of charcoal. The latter institution found that the cost of operating a 35 horsepower four cylinder tractor with gasoline on plowing was from six to seven times greater than when gas was used. The gas produced about 25 per cent less power per unit than gasoline and caused the use of more lubricating oil. Valves, valve seats, and spark plugs were left in better condition by the gas than by gasoline, however.

The Massachusetts Institute of Technology, the Texas station, the British Ministry of Agriculture, the National Physical Laboratory of Great Britain, and the French Academy of Science have been especially active during the past year in studies of lubricating oils and of the lubrication of internal-combustion engines.

The work at the Texas station seems to have been undergoing preliminary analysis and planning for a year and a half. Apparently it has narrowed down to a study of the lubrication of engine bearings, the purpose being to establish the physical and chemical properties of lubricating oils necessary to meet the conditions of proper lubrication of crankshaft and connecting-rod bearings under different severe conditions of operation. This work will probably involve cooperation with the department of chemistry, and will thus not be limited to lubricating oils available. It is apparently intended to find out first what a lubricating oil should accomplish under certain conditions, and then proceed to develop the oil itself. It is understood, that the support of the agricultural experiment station has been secured for this work. Striking features of this project are, first, that the agricultural engineering department is taking plenty of time in the preliminary analysis and study of the subject in order

that the project may be placed in the best of shape for intelligent prosecution, and, second, the intention seems to be to center all efforts on this one project and bring it to satisfactory completion before starting something else. This might be a questionable procedure under other circumstances, but if one considers the magnitude and far-reaching fundamental importance of the project the wisdom of careful and painstaking proportion and of concentration of effort during actual prosecution is apparent.

As a preliminary to a similar project, studies have been conducted in France on frictional losses in internal-combustion motors. It has been possible so far to establish a definite mathematical relation between friction losses and mean pressure for certain experimental motors, and an effort is being made to broaden this to include definite classes and groups of motors. The Massachusetts Institute of Technology has conducted fundamental studies on the mechanism of lubrication and the measurement of the property of oiliness. The National Physical Laboratory of Great Britain has been working on the improvement of the lubricating properties of mineral oils by the addition of fatty acids. A significant general result of these studies is that a very considerable reduction in the static coefficient of friction of mineral oil was effected by the addition of as little as 0.1 per cent of fatty acid whether as pure oleic acid, acid rape oil, or rape oil fatty acids. The rape oil fatty acids were the most effective.

Valuable studies of far-reaching importance have also been conducted on crankcase oil dilution problems by certain private institutions. These have led to the development of automatic crankcase oil regeneration systems and methods which are opening up new and interesting fields of study.

According to inspection reports the tractor testing work at the Nebraska station, under the state law, is still in progress. Of course, such work is not exactly research, but apparently it is opening up some very interesting avenues of study and drawing forcible attention to numerous unsolved problems for future study. There have been numerous other tractor projects apparently in operation at some of the colleges and stations, but these have obviously been so general in nature as to not warrant any special mention.

As usual the so-called economic surveys of tractors have been given considerable attention. In addition to the institutions mentioned in last year's report, the Montana, West Virginia, and New Hampshire stations have become interested in tractor economics. The U. S. Department of Agriculture has also continued its studies along this line but in a much more comprehensive manner than would be possible or feasible for a state institution.

While the Research Committee does not condemn these economic studies, it has felt that their value has quite definite limitations. With the large number of tractors on the market it is no longer an intelligent procedure to accept them at their face value. In fact, there seems to be a tendency on the part of some of the agricultural engineering departments to inject a little more engineering into these economic studies. It takes more time and money and results are not so quickly obtained, but they are much more valuable when available. For instance, there is now a tendency at certain state institutions to include in the customary questionnaire to farmers and tractor users questions as to exactly why a particular tractor failed or used too much fuel, water, or lubricating oil. And the tendency seems to be growing to stick to these questions until they are satisfactorily answered. This has resulted in the opening up of problems for study and experimentation on tractors which might otherwise remain unknown and unsolved.

It is known that experimental and developmental work on problems of such origin has been in progress at the Georgia agricultural college, for instance. The reclamation of worn valves, the regrinding of cylinders, and the development of new designs of pistons and cylinders to make regrinding unnecessary have been important subjects of such investigations.

It is believed to be becoming more strongly evident that an intelligent admixture of engineering precision in economic surveys of tractors as well as in surveys of other machines will tend not only to reveal successes and failures, but also the exact causes therefor, thereby pointing the way to further improvement and development and preventing the unnecessary repetition of mistakes.

Very few general tractor trials were conducted during the year, and this type of engineering pastime seems to be losing in popularity. In fact, the British Ministry of Agriculture in reporting on the Shrawardine tractor trials concludes that the conditions under which such trials are conducted do not give sufficient time or opportunity for adequate testing. It is considered that trials, including sustained tests which will extend to laboratory work on materials and soils and which will be continued as far as the resultant crop, are more to be desired. On the other hand, the Egyptian Ministry of Agriculture conducted two different sets of tractor trials which resulted in the striking conclusion that on Egyptian soils wheel tractors are more efficient than tracklaying types.

Almost every agricultural college and experiment station has recently evinced some interest in the improvement of farm machinery other than tractors. This general interest has in a number of cases narrowed down to a study of certain definite factors or features. The draft of farm implements especially has been engaging the attention of a number of institutions and is a striking instance of the growth of interest in investigational work. Two years ago this subject was being studied by only one or two institutions. Now at least six of our experiment stations are actively engaged in prosecuting projects of study on one or more phases of the draft of farm implements and the factors affecting it. These include the New York Cornell, California, Montana, Iowa, Nebraska, and Missouri stations, and it is believed that other colleges and stations are doing similar work of which there is no record available.

The New York Cornell station has been developing a traction dynamometer for the testing of heavy draft implements and perfecting integrating devices for studying the records. The California station has studied the power requirements of plowing, with special reference to the economic limits of animal and mechanical power. The Iowa station has apparently completed its well-known study of the influence of speed upon the draft of plows and is engaged in a study of the factors affecting the draft of farm wagons. A comparative study of the work and merits of round and cutaway blades for disk harrows at the Iowa station showed that the cutaway blade causes from 10 to 20 per cent heavier draft and penetrates more deeply than the round blade.

The Missouri station has had a rather voluminous project in operation on the draft of various farm implements, but more especially it seems of tillage machines. The influence on draft of different soil types and of soil treatments has also been studied. Recent results have shown that, while the draft of plows is materially decreased by disking first, the total amount of work done is greater than to plow without disking in spite of the greater draft. The draft per foot of width of a single disk penetrating an average depth of 1.25 inches in silt loam corn soil was 81 pounds and when penetrating three inches in silt loam soil which had been fall plowed it was 108 pounds. The station is also interested in the draft of wagons on different kinds of roads.

The plow draft investigations at the Nebraska station constitute probably the best planned and equipped project on the subject on record. This project is apparently an outgrowth of years of preliminary study and planning which

have been narrowed down to a searching investigation of certain specific fundamental factors. Recent results of a large number of plowing tests made under varying depths and speeds varied widely in the case of speed draft tests, but were fairly consistent for depth draft tests. The increase in draft due to increase in depth of from 5 to 10 inches was approximately 27 per cent of the draft at 5 inches. Tests to determine the draft of a disk harrow for different angles of the disk sections and the effect of weight on the draft showed that the increase in draft due to fully angling the section was about 175 per cent of the draft at no angle. A weight of 180 pounds increased the draft 60 per cent. Attention should also be drawn to the studies of resistances to the translation of motor vehicles being conducted by the Iowa engineering experiment station. These have already indicated the importance of rolling resistance and of low-grade surfaces.

The Iowa station also has a project on the standardization of farm machinery, a cooperative project with the agronomy division on experimental methods for machinery investigations, a project on grain grading and cleaning machinery, and a cooperative project with the soils division on limestone and fertilizer spreaders. It is understood that the last named project has been completed. In this project tests of commercial limestone spreaders and a study of the various methods of handling limestone showed that the desirable features of a limestone spreader are that it should be able to handle wet or dry stone, it should pass stones without injury to the machine, and it should spread uniformly and be calibrated with reasonable accuracy. The studies showed that the revolving finger type of distributor gives the most accurate calibration and uniform distribution, and that the most desirable type of spreader would be in the form of a trailer behind a loaded wagon, the material being shoveled directly from the wagon to the spreader. While this type did not spread as uniformly as some others, it handled larger stones without breakage. None of the commercial machines tested fully met the above requirements, so the station proceeded to develop a machine which worked very satisfactorily. It is desired to draw special attention to the manner in which this project was planned and conducted. It began with a study of what a limestone spreader should do, passed through the stages of testing available types, and ended by the development of a fairly satisfactory machine.

A similar study has been conducted at the Michigan station where a lime spreader was developed to be attached to the rear end of the wagon box and operated by a rocker arm dropping from peg to peg on a disk attached to and turning with the rear wheels of the wagon. The rocker arm moves a board under the hopper which serves as an agitator. The jarring action of the rocker arm upon the agitator and box serve to feed down the lime. This machine was successfully tested with pulverized limestone both dry and damp.

The Alabama station has a project on fertilizer distributing equipment, which it is understood is still in the process of preliminary study, to determine the necessary and desirable features of such equipment.

The Wisconsin station has been studying the efficiency of various types of silage cutters and developing a marsh plow for breaking new land. The Arkansas station has been engaged in a study in cooperation with the agronomy and farm management departments on machinery necessary to space cotton with acid-delinted seed to save the cost of chopping. That station is also engaged in a survey of farm machinery conditions in Arkansas.

The New York Cornell station has been studying the thermal efficiency and mechanical reliability of the Hvid engine. This project should be of interest since it is known that certain tractor and farm engine manufacturers are interested in the development of this type of motor. The Michigan station has two projects, one on the efficiency of farm machinery and the other on power machinery, the research status of which is not known.

The New York Geneva, Connecticut Storrs, Iowa, and South Dakota stations have projects on milking machines. It is understood that these projects are confined either to the dairy or bacteriology departments. It is believed that here are instances in which cooperation with the agricultural engineering departments might be profitable, especially where efforts are being made to improve the efficiency of milking machines. The New Zealand Department of Agriculture has found such a cooperative arrangement to be quite profitable, judging from the results of a recent study of the use of electric power for milking plants. Records from five plants for twelve consecutive months showed that the most effective application of electric power to milking machine work under New Zealand conditions consists of a small self-contained outfit, comprising an electric motor, vacuum pump, cream separator, small water supply pump, and a 10-gallon water cistern, with the necessary switch gear, all mounted on a compact hardwood base plate.

Among the more miscellaneous machinery investigations, the wearing tests of plowshares at the California station should be mentioned. It has been found so far that the least wear is shown by chilled cast-iron shares, slightly more by soft center steel, and considerably more by manganese steel. While these tests are perhaps more or less preliminary in nature, yet the results obtained are quite interesting and open up what may be a field of research of far-reaching importance in plow development and design. The writer has always advocated a more thorough study of the possibilities of cast iron and semi-steel for cultivating machinery, and the results of this study so far appear to be quite significant in that connection.

Studies at the Experimental Institute of Mechanical Agriculture of Argentina on windmills have resulted in the development of an improved type adapted for the operation of a vertical double-acting plunger pump.

Studies by the British Ministry of Agriculture on the economics of harvesting oats with a horse-drawn binder, a tractor-drawn binder, a tractor and two binders, and a tractor-drawn combination binder and shocker showed that mechanical binding effected a saving of 75 per cent in hand labor over hand binding. The combined operations of binding and shocking gave results considerably superior to the two binders plus hand shocking. This project has resulted in the development of a fairly satisfactory mechanical shocker.

The British Ministry of Agriculture has also been engaged in studies of potato diggers. The preliminary analysis and study showed that a successful machine should bring the potatoes well to the surface, leave them exposed and undamaged, and the draft of the machine must be comparatively light. The rotary or spinner type gave the best results, and its general principles are considered to be sound, but further research is necessary into the problems of speed, angle of time, projecting load, and the resultant effect on the potatoes as well as the ease of digging. The advantages of a low speed gear and an angle of tine of 45 degrees in a rotary machine were reflected in the smaller proportion of damaged potatoes and the small number left in the ground.

A final piece of machinery research of interest to agricultural engineers which should be mentioned is that conducted by the U. S. Bureau of Standards on the power lost as heat in automobile tires when operated under different conditions of axle load, inflation pressure, speed, and tractive effort. The loss increased directly with an increase in speed or axle load and increased quite rapidly with a decrease in air pressure below the standard. Tractive effort had a comparatively small effect upon power loss. Fabric tires as a class showed considerably greater losses than cord tires.

FARM BUILDINGS

There is a record of only seventeen projects of study on farm buildings and structures in force or completed during the year at the state experiment stations. During the previous two years almost every agricultural college and experiment station had some sort of a farm structures project, but it seems that many of these have been so general and indefinite as to reach the limits of their usefulness and have become inactive from lack of support. As in the case of farm machinery projects, experiment station directors and other officials administering research and investigational funds are no longer much interested in supporting farm building and structures projects unless they relate to the development of some specific and important feature, and the line of approach and method of procedure are well worked out.

The Iowa college and experiment station, with its many and varied farm building projects, has apparently been one of those to realize this and to act accordingly. Out of nine or ten general projects several have been discontinued and others have been completed. In their place are found a few more definite and better planned projects tending to nail down certain fundamental facts regarding a few of the more important features of farm structures, most of which are probably more or less well known.

The Michigan station has been studying the framing of barns and the ventilation of potato storage houses. The latter study, which was discussed with the writer over two years ago, has indicated in its preliminary features that successful potato storage under Michigan conditions depends upon the maintenance of a dry atmosphere and a temperature as low as from 33 to 38 degrees Fahrenheit. To provide movement of air through as well as around potato piles it has been found that the bins should not be wider than 8 feet nor deeper than 10 feet, and they should be kept some distance from the outside walls. Both the King and Rutherford systems have been successfully used.

It is understood that the Missouri station has continued its silo and silage investigations which include wall construction and deterioration, capacities, etc. This work undoubtedly includes some research features. It is to be noted that it has been in operation since 1913. A similar study is in progress at the Guam station.

A great majority of the stations have continued their work on poultry houses. Prominent among these are the Kansas, Kentucky, Pennsylvania, Montana, Washington, and New Jersey stations. It is noted that most of this work has been in charge of poultry husbandry departments exclusively. While valuable data has undoubtedly been secured, it frequently exists in no very usable shape, and an intelligent application of it to variable conditions is often quite difficult. It is thought that the practice of conducting such studies in cooperation with the agricultural engineers should be encouraged in some cases. Poultry houses, especially for large-scale operations, call for intelligent design and construction involving a knowledge of materials, ventilation, and structural design which anyone can not possibly possess unless especially trained therein. The amount of study being conducted on the subject indicates that it has never been thoroughly solved. An intelligent cooperation with the agricultural engineering divisions may be a step of considerable importance in placing such work on a more firm and permanent basis.

The workers on the subject of building ventilation now have an ally in the U. S. Public Health Service. That institution has apparently been studying the efficiency of various kinds of ventilating ducts, if not directly at least through some of its collaborators. Uniformity of air distribution through ducts operating on different principles was especially studied.

The work of the U. S. Department of Agriculture on farm building ventilation is so well known as to need no description. It is felt that this work is developing into a piece of the highest type of research.

The Ohio agricultural college has engaged in a study of braced rafter barn framing, with special reference to its adaptation to dairy barns. The Nebraska station has apparently completed its several years study of hog houses, and the British Ministry of Agriculture is engaged in a study of the design and construction of cow sheds to meet agricultural conditions in England.

It is understood that the Kentucky station has been and is now engaged in the preliminary analysis and planning of a project on tobacco-curing barns. Recent developments indicate that this project may involve cooperation between the agricultural engineers, the tobacco specialists, and plant pathologists. It is desired to draw special attention to the intelligent and searching manner in which it is proposed to approach the study of this subject. The purpose, as explained to the writer, is to find out first exactly what will be required of barns to properly cure different grades of tobacco, and then to proceed with development on that basis.

The Agricultural Society of Austria has been engaged in studies of floors for farm buildings. These have indicated in their preliminary phases that clinkers, clinker concrete, and sand cement floors are among the better materials for stock barns.

The South African Department of Agriculture has continued its studies of pise-de-terre farm buildings, and one of our private institutions has made a valuable contribution on the preservation of decaying wood roofs. This study showed that decay in roofs is usually greatest in planks and beams at bearings, because, due to the additional insulating properties of the supporting members, the locus of moisture dips. Tops of roof rafters and girders rot first, and decay is usually more active near ventilators and cold conductor pipes. The treatment consists in removing the water supply from the fungus causing decay by preventing condensation through insulation of the outer roof surface.

DRAINAGE

The study of soil drainage at the state experiment stations has apparently been undergoing somewhat of a change for the better during the past year. It was stated in last year's report that considerable of the work in progress on drainage was not of a very high order of research. It is noted that the tendency to overhaul drainage projects with a view to injecting some more obviously research features into the work seems to be growing.

For instance, the North Carolina station has a cooperative project on the efficiency of underdrains which has included studies of run-off, the relation of run-off to rainfall, and the lowering of ground water level. While these studies have yielded considerable data and have considered different soil types, it has been realized that they have dealt largely with the manipulation of engineering hydraulic principles without sufficient reference to the soil itself. The purpose, as related to the writer, is to replan and enlarge some of this work with a view to studying the influence of the physical and chemical properties of the soil and of different soil treatments and crops on underground run-off.

The realization of the importance of such a procedure was brought about when certain tenacious clay soils were encountered, in which it was found that the application of ordinary drainage measures was unsuccessful. The importance of such a modification of customary procedure has also been recognized at the Georgia agricultural college and at the Alabama, Texas, Kentucky, and Virginia stations. It is also believed that this procedure is finding some considerable favor with the U. S. Department of Agriculture.

since that institution seems to be gradually confining its drainage activities to the more strictly research features of the subject, many of which are already well known.

In connection with the study of the influence of the physical and chemical properties of soil on underdrainage, attention may well be drawn to the fact that certain German agricultural experiment stations have developed some rather definite hydraulic principles for German soils. Some of the preliminary studies of the relative permeabilities of soils as influenced by their content of fine and of coarse particles have shown that permeability increases as the content of coarser particles increases. Rather definite relations have been developed between permeability and clay content, calcium carbonate content, relative speed of sedimentation, so-called specific soil surface, specific weight, and other physical factors.

The Minnesota station has a project on the correlation of land and crop values with cost of drainage operating under the division of agricultural engineering. This subject seems to be gaining considerably in importance. It is understood that the Virginia station is planning a similar project for next year, but along much more comprehensive lines. The purpose, as related to the writer, is to effect a cooperative arrangement between the agricultural engineering, soils, field crops, and farm economics divisions to determine the economic status of drainage systems which have already been constructed in Virginia.

The Minnesota station is also engaged in studies of drainage and water control on peat lands and of the relative efficiencies of different depths and spacing of tile drainage lines. The Wisconsin station has been studying the settlement of peat after drainage.

The Oregon station has three projects of a general nature on the drainage of alkali and tide lands, and a rather definite project on the influence of clover, lime, and manure on the drainage of white lands. The Michigan, Montana, Mississippi, New Mexico, and California stations have similar drainage projects apparently of a general nature.

With reference to surface run-off, attention should be drawn to a study by the U. S. Weather Bureau in progress to determine the influence of forests and vegetation on run-off. Also the Bureau of Public Roads of the U. S. Department of Agriculture has recently studied flow through cleared and uncleared floodways, which showed a difference in discharge capacity between cleared and uncleared channels of 62.5 per cent.

A review of the soils projects at the different experiment stations indicates that there are in operation at least nineteen projects at as many stations on the relation of soil moisture and soil moisture movement to the physical and chemical properties of soils. The agricultural subject of soils and the engineering subject of drainage are obviously quite closely related. It would seem, therefore, that cases might frequently occur in which cooperation between the soils and agricultural engineering departments would be profitable in establishing fundamental hydraulic principles governing the under-drainage of soils.

IRRIGATION

Irrigation is an old and well-organized subject, and the investigational work therein has been extensive. Practically every state experiment station in the irrigated West has supported its quota of research projects in irrigation during the year. There is a record of at least forty active projects in twelve states. It is true that some of these are too indefinite or general in plan to lay claim to a research status. The majority, however, are planned along research lines, and it is difficult to determine which are the more important.

These studies have covered almost all phases of irrigation. One of the newer features of the work is the development of pump irrigation. This has been studied at the Arizona, Utah, Montana, and Nebraska stations, and further work along this line is being planned at the New Mexico station. Duty of water has been studied at the Utah, Nebraska, California, Nevada, Oregon, and Montana stations. The Montana and Colorado stations are engaged in seepage studies, and the Colorado and Arizona stations are studying evaporation. The Colorado station has been especially active in studying the measurement of water, particularly with the Venturi flume and current meter. Similar work has been conducted by the Egyptian Ministry of Public Works and the U. S. Department of Agriculture. The Oregon station has studied methods of irrigation water distribution. In this study the strip border method was considered with reference to head, kind of soil, and width and length of border. Similar studies have been in progress in New Zealand, and it is understood that the California station has such a project under consideration. The Utah station has engaged in studies of the composition of irrigation waters, and the Arizona, New Mexico, and Utah stations have been interested in studies of ground water.

Practically all of the stations dealing with irrigation have studied alkali soils and their reclamation by various treatments. The Nevada, Utah, and California stations and the Department of Agriculture of Canada have been especially active in this respect. The Utah station has conducted studies on the capacities of soils for irrigation water. A summary of data from a number of large irrigation projects has been gathered by the U. S. Reclamation Service, indicating that ordinarily 50 per cent of the water diverted for irrigation purposes becomes a source of return flow. The U. S. Reclamation Service has also reported studies on coefficients of discharge for suppressed submerged orifices, rating curves for canal head gate, metal flumes, concrete canal linings, and methods for the cleaning of canals.

The U. S. Department of Agriculture has been engaged in almost every phase of irrigation study and appears to be the leader in this work. It is to be noted that a large part of the state station work has been done in cooperation with the federal department.

About the only recommendation that can be made regarding the conduct of irrigation research is that the importance of considering the physical and chemical properties of the soil, the crops grown, and the soil treatments be not lost sight of. An instance of the importance of considering these factors occurred recently at one of the state stations where, through the cooperation of the soils and plant pathology departments, discrepancies and nonuniformity in the results of deep percolation and duty of water studies were discovered and eliminated, thus preserving the accuracy of the results.

FARM WATER SUPPLY AND SEWAGE DISPOSAL

Numerous well-meant attempts have been made during the year to secure so-called practical information on the subject of farm sewage disposal for presentation to farmers. Some of these attempts are more or less successful, but undoubtedly they are more frequently the result of luck than of an exercise of fundamental knowledge.

The volume of practical information on this subject which is issued from some sources is most astounding, in view of the fact that institutions like the Rockefeller Institute of Medical Research, the New Jersey, Montana, Illinois, New York Cornell and other experiment stations, and the U. S. Public Health Service are investing funds in attempts to get at the fundamental principles of the subject. One needs only to summarize the existing fundamental information on the subject to realize that the greater part of our present so-called practical knowledge is based for the most part on guess work, mechanical skill, and the results of a few poorly planned experiments of very limited applicability. Much of the available information is not new at all and is obviously of quite limited fundamental importance.

In spite of the general lack of support of the subject, a few institutions have sifted the available knowledge of the subject down to the little bit that is of fundamental importance, and with this as a basis are beginning some actual research planned to bring out the scientific and engineering facts of the matter.

The Illinois station is planning a project to bring out the relation between septic tank dimensions and the chemical and biological changes taking place therein. It is proposed to conduct this work in cooperation with the state water survey and with such other divisions of the experiment station as have an interest in any part of the matter. It is understood that the system of grouping of conditions to be met is to be used as a basis. This system was proposed in a report appearing in the 1917 transactions of the American Society of Agricultural Engineers. The New Jersey station has continued its study of the biology of sewage disposal, and the Montana station is apparently still engaged in an effort to find out what a septic tank and an Imhoff tank are all about. The Michigan station has had a project in operation on the relation of the design of sewage disposal systems to successful operation. While this project sounds rather general, it is understood to embody some specific research features.

The New York Cornell station has two projects which should be mentioned, one on the relation of septic tank design to the accumulation of sludge and scum and the discharge of suspended solids in the effluent and another on the effectiveness of various dosing methods in subsurface absorption tile receiving the effluent from small domestic tanks. The Missouri and Minnesota stations also have sewage disposal projects in operation.

The Kansas agricultural college is understood to be planning a farm sewage disposal project. While no information is available as to the present status of the project, it is known that some considerable planning of a preliminary nature has been in progress, leading to a study which will require from five to ten years for completion.

The Rockefeller Institute of Medical Research has been engaged in a most exhaustive study of soil pollution and the relation of the various types of privies to the spread of intestinal infections. Some of the results so far obtained have occasioned considerable comment and controversy, but it is hard to disprove them with our present lack of fundamental information. For instance, it was found that both typhoid and dysentery bacilli died in from one to five days in septic tanks, but the typhoid bacilli survived from 10 to 15 days in solid feces, and the dysentery bacilli not longer than five days. The paratyphoid bacilli were the most resistant members of the group. These are supposed to be encouraging statements, but when one considers the variable conditions of flow under which many of the so-called simple practical septic tanks, consisting of a square shallow box, operate there is very little protection in them, especially when retention periods are shortened by increased flow and final disposal is inadequate or non-existent.

The conclusion is drawn that in moderately compact clay, sand clay, or sandy soil *free from cracks*, the possibility of pollution of ground water is negligible, provided the ground water level is more than 10 feet from the polluted area. It is to be noted that this conclusion is based on a very limited set of conditions only, and that alarming reservations are made for many other conditions.

The Ontario Agricultural College is engaged in an interesting study of the problems of freezing in septic tanks and absorption tile systems. The preliminary results show that the temperature in septic tanks is constantly higher than that of the surrounding air, and that fluctuations in temperature cover a much smaller range. This is true to an even greater extent in the tile. With a minimum outside temperature of 6 degrees Fahrenheit the minimum temperature in the tile was 34 degrees, in the digestion chamber 44 degrees, and in the flushing chamber 34 degrees.

The Wisconsin State Board of Health has completed an eight year study of sewage disposal systems for farm and rural homes and schools. These studies indicate that the cesspool is in general an obsolete and unsatisfactory method of sewage disposal. While it is considered that a septic tank is necessary to lessen the offensiveness of the sewage and place it in better physical condition for final treatment, it has been invariably found that septic tank effluent is just as dangerous to health as the raw sewage. The Idaho station, on the other hand, has reported studies on farm septic tanks from which the deduction is made that the materials driven into a septic tank are changed to simple harmless materials. They are said to enter the tank as a dirty, greasy mixture and leave it in a simple and sanitary form. It is further stated that the effluent may be run into an open field because it contains only completely decomposed substances and is not insanitary. This surprising statement is somewhat opposed to that made above by the Wisconsin State Board of Health and statements made by several other institutions. It is suspected that it is due in part at least to the fact that the soils in parts of Idaho are very porous and highly absorptive, making any final treatment of septic tank effluent unnecessary in many cases.

The Department of Health of New Jersey has made a study of Imhoff tanks for industrial and institutional sewage disposal which would indicate that the installation of this type of apparatus has been more or less promiscuous.

Studies in Great Britain on the absorptive power of sand filters have shown that a sand filter freshly prepared is capable of absorbing fairly large amounts of ammonia and dissolved organic substances, and that this action takes place rapidly. Sand that has ceased to absorb dissolved substances must be thoroughly washed before it again becomes active.

The Department of Agriculture and Technical Instruction of Ireland has been engaged in studies on the purification of creamery sewage by means of septic tanks and activated sludge treatment. These have so far indicated the advantage of a combination of these two treatments.

The Kentucky agricultural college has recently reported a study of farm sewage disposal systems which indicated the importance of final treatment of septic tank effluent for the different farm conditions encountered in Kentucky. It is also understood that that institution is studying small water supply systems. The Kansas agricultural college is also interested in that subject, with special reference to soft water cisterns and filters. The New York college of agriculture has gone into the subject of water supply for farms probably as thoroughly as any other institution, and has been paying special attention to plumbing.

The North Carolina college and station have recently evinced considerable interest in knowing more about hydraulic rams. It is understood that rams have been installed under almost every conceivable condition, and it has been found that the old rule-of-thumb friction formulas do not always hold. In addition, curious losses of head have been observed under certain conditions which cannot be explained on the basis of known hydraulic principles. An analysis of the subject has indicated that the present formulas, theories, and frictional coefficients are apparently not based on any very searching studies of hydraulic rams, but are known hydraulic principles for the most part which have been arbitrarily applied to hydraulic rams. While no special provision has been made for this work, it is understood to be planned eventually to make a thorough analysis and study of the subject to establish once and for all the engineering and hydraulic principles for this important apparatus.

(Concluded in the April issue)

The Pacific Coast Meeting

A MEETING of the A. S. A. E. members on the Pacific Coast and others interested in the activities of the Society was held in San Francisco December 15 principally for the purpose of discussing the question of organizing a Pacific Coast or western section of the Society, to discuss agricultural-engineering problems peculiar to the western part of the United States, and also to arouse interest in the holding of a meeting of the Society on the Coast possibly in 1923. Approximately seventy-five agricultural engineers registered at the meeting, which consisted of a morning and afternoon session devoted to business and technical discussions followed by a banquet in the evening. David Weeks of the University of California, and at that time a vice-president of the Society, presided at the meeting.

The professional program included some very interesting and valuable papers presented by the Pacific Coast agricultural engineers. Dr. Elwood Mead, head of the department of rural institutions at the University of California, and the leading authority on land settlement work, spoke briefly on the opportunities for agricultural engineers in land settlement. Max E. Cook, farmstead engineer in the division of land settlement of the California State Department of Public Works, addressed the meeting on his work in farmstead engineering at the Delhi settlement. F. S. Tillinghast, chief engineer of the reclamation project in the Sutter Basin, discussed the drainage, irrigation, and reclamation phases of that project. Dr. Samuel Fortier, associate chief of the division of agricultural engineering in the U. S. Department of Agriculture, presented an address entitled "Agriculture and the Agricultural Engineer." Paul Weeks, assistant director of engineering for the Holt Manufacturing Company, delivered an address on the subject, "Tractors and the Ideals of High Class Construction Necessary in their Manufacture." A. H. Hoffman, of the department of agricultural engineering of the University of California, discussed some of the lines of experimental work in agricultural engineering being made at the University Farm at Davis. S. H. Beckett, associate professor of irrigation investigations and practice in the University of California, discussed the control of the underground water table as a factor in alkali prevention.

A very definite and overwhelming sentiment was expressed favoring a meeting of the Society, preferably in San Francisco, during 1923, or at least not later than 1924. The development of the Pacific Coast is to a large extent the result of efforts of agricultural engineers, and in recognition of the progress that has been made on the Pacific Coast in agricultural engineering, the members in that section of the country strongly urge that a meeting presided over by officers of the Society, if not a regular annual meeting, be held there at the earliest possible date.

The question of whether to organize a local section of the Society on the west coast to include the arid west, the north Pacific Coast and the Rocky Mountain section, or to have meetings under the supervision of the officers of the national society, was discussed at considerable length, but the matter presented so many different angles that no definite decision or recommendation was made. This, however, with other matters looking to furthering the interests of the Society on the Pacific Coast, was referred to a committee consisting of L. J. Fletcher, L. W. Symmes, Elwood Mead, Max E. Cook, Paul Weeks, and David Weeks.

The Secretary's Letter

ON MARCH 1 the A. S. A. E. headquarters inaugurated a new idea in the shape of "the Secretary's letter," which will be issued monthly to all members of the Society, for the purpose of keeping all members in closer touch with the Society and individual member activities. Members who fail to receive the Secretary's letter are requested to notify headquarters, giving their correct address.

New A.S.A.E. Members

GEORGE A. ALTGELT, Guantanamo Sugar Co., Guantanamo, Cuba. (Member).

C. C. KNIGHT, LAVRAS, E. de Minas, Brazil, South America. (Member).

WALTER W. SCHUYLER, United Fruit Company, Guaro, Oriente, Cuba. (Member).

F. E. STAEBNER, Bureau of Public Roads, Washington, D. C. (Member).

W. K. WINTERHALTER, 1409 Alexander Bldg., San Francisco, California. (Member).

EMPLOYMENT SERVICE

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of AGRICULTURAL ENGINEERING. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Non-members, as well as members, are privileged to use the "Positions Available" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

The Secretary receives at frequent intervals bulletins from the Engineering Societies' Service Bureau, 29 West 39th Street, New York City, listing the "positions open" as reported by member societies. Copies of these bulletins are sent to the "men available" listed below, as soon as received.

Men Available

MECHANICAL AND ELECTRICAL ENGINEER, graduate of Cornell University and Armour Institute, with nineteen years of practical experience in designing, manufacturing, and marketing gasoline engines, automobiles, motor trucks and tractors, having specialized particularly on internal-combustion motors and their application, prefers mechanical work cooperating with the different manufacturing and sales departments along the lines of sales engineering, or other work into which his qualifications would fit. MA-104

AGRICULTURAL ENGINEER wants position in southwest. Graduate of University of Illinois 1915, five years practical experience on Illinois farm with power equipment, two years in charge of the agricultural engineering department New Mexico College of Agriculture; considerable garage experience and service experience on unit power and light plants. Also one summer in Philadelphia battery service station. MA-106

AGRICULTURAL ENGINEER, graduate in mechanical engineering at Michigan Agricultural College, desires position teaching all kinds of farm machinery or automotive work, or with some farm-equipment manufacturer. Will be available April 1, 1922. Has served one year as instructor in tractors and trucks, and one year conducting service schools for a leading tractor manufacturer. Can furnish best of references. MA-110

AGRICULTURAL ENGINEER, graduating from University of Illinois at end of present semester (available March 1, 1923) would like position in service department or experimental department of company manufacturing tractors or farm machinery. Three years' practical farm experience in West and one year in Illinois. Age 27. Unmarried. MA-116.

Positions Open

DRAFTSMAN who has had experience in designing and manufacturing threshing machinery with reliable, well-established farm-machinery manufacturer in central Pennsylvania. PO-1.

DRAFTSMAN to assist in designing threshing machinery and gas tractors with well-established manufacturer of farm machinery in the East. PO-2.

STUDENT FELLOWS OR INSTRUCTOR IN DRAINAGE. The department of soils of the Oregon State Agricultural College will be able to use two student fellows, one in pure soils and one in soil irrigation and drainage work, if they can be promptly located, or an instructor in drainage if fellows are now secured. Write W. L. Powers, chief in soils, Corvallis, Oregon. PO-3.

STUDENT FELLOW IN AGRICULTURAL ENGINEERING. There will be an opening beginning September, 1923, for a student fellow in agricultural engineering at the Virginia Polytechnic Institute. Write Charles E. Seitz, department of agricultural engineering, Virginia Polytechnic Institute, Blacksburg, Virginia. PO-4.